

SEARCH FOR NARROW PION-PROTON STATES IN S-CHANNEL AT EPECUR: EXPERIMENT STATUS

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Abstract

An experiment EPECUR, aimed at the search of the cryptoexotic non-strange member of the pentaquark antidecuplet, started its operation at a pion beam line of the ITEP 10 GeV proton synchrotron. The invariant mass range of the interest (1610-1770) MeV will be scanned for a narrow state in the pion-proton and kaon-lambda systems in the formation-type experiment. The scan in the s-channel is supposed to be done by the variation of the incident π^- -momentum and its measurement with the accuracy of up to 0.1% with a set of 1 mm pitch proportional chambers located in the first focus of the beam line. The reactions under the study will be identified by a magnetless spectrometer based on wire drift chambers with a hexagonal structure. Because the background suppression in this experiment depends on the angular resolution, the amount of matter in the chambers and setup is minimized to reduce multiple scattering. The differential cross section of the elastic π^-p -scattering on a liquid hydrogen target in the region of the diffractive minimum will be measured with statistical accuracy 0.5% in 1 MeV steps in terms of the invariant mass. For $K_S^0\Lambda^0$ -production the total cross section will be measured with 1% statistical accuracy in the same steps. An important byproduct of this experiment will be a very accurate study of Λ polarization. The setup was assembled and tested in December 2008 and in April 2009 we had the very first physics run. About $0.5 \cdot 10^9$ triggers were written to disk covering pion beam momentum range 940-1135 MeV/c. The talk covers the experimental setup and the current status.

An interest to this experiment originated with the discovery in 2003 by the two experiments LEPS [1] and DIANA [2] a new baryonic state θ^+ with positive strangeness and very small width. Later appeared several strong results where the state was not seen [3] but recent results from LEPS [4] and DIANA [5] still insist on the evidence for this resonance. Quantum numbers of θ^+ are not measured but it is believed that it belongs to pentaquark antidecuplet predicted in 1997 by D. Diakonov, V. Petrov and M. Polyakov [6]. In this case there should also exist a non-strange neutral resonance P11 with mass near 1700 MeV. Certain hints in favour of its presence were found in the modified PWA of GWU group [7] at masses 1680 and 1730 MeV [8]. Recently an indication for this narrow

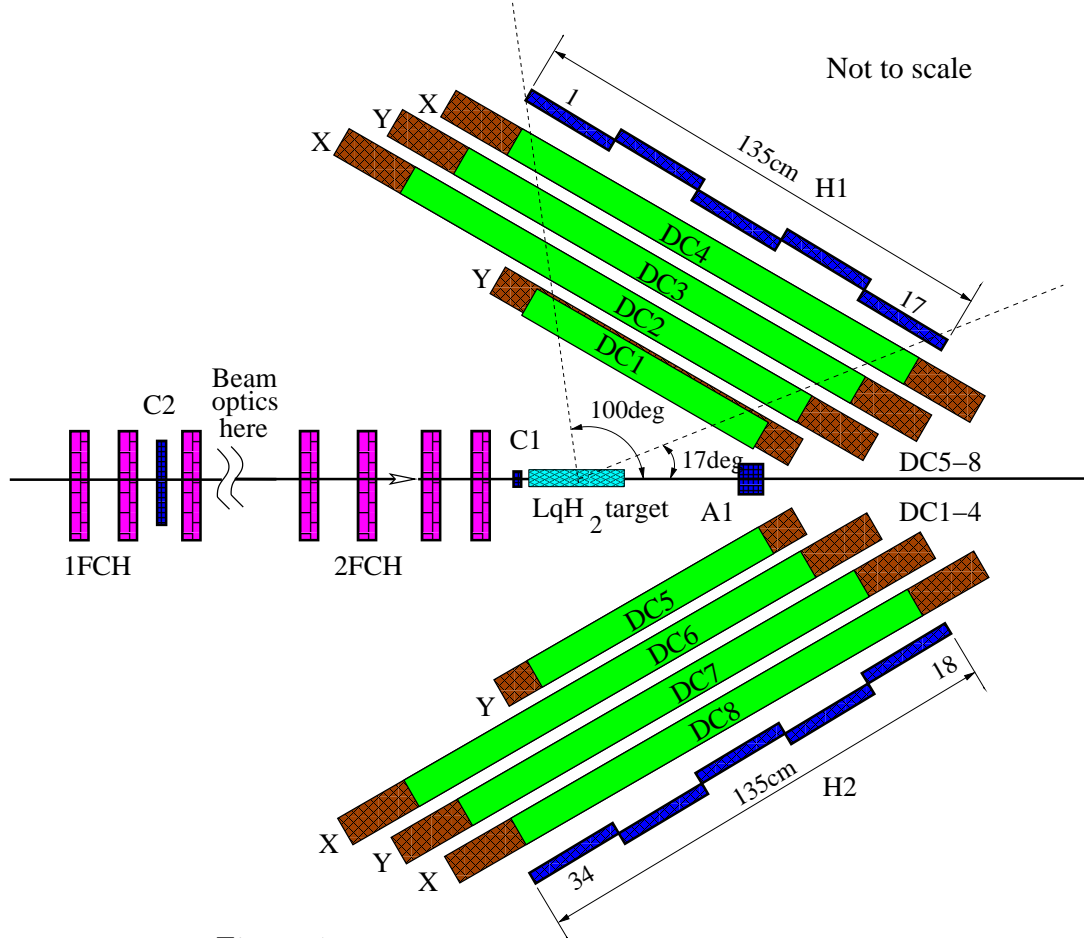


Figure 1: Experimental layout for π^-p elastic scattering.

state was found in η -photoproduction on deuteron in GRAAL [9] and some other experiments. The structure observed has mass 1685 MeV and width < 30 MeV, which was determined by the detector resolution. Our idea is to search for P11(1700) in formation-type experiment on a pion beam [10]. Precise measurement of the beam momentum and fair statistics will allow us to do a scan with unprecedented invariant mass resolution. We plan to measure differential cross sections of the reactions $\pi^-p \rightarrow \pi^-p$ and $\pi^-p \rightarrow K_S^0 \Lambda^0$ with high statistics and better than a MeV invariant mass resolution. If the resonance does exist our experiment will provide statistically significant result and we will measure its width with the precision better than 0.7 MeV.

The layout dedicated to the elastic scattering measurement is shown in fig. 1. The main parts are: proportional chambers (**1FCH** and **2FCH**), drift chambers (**DC1-8**), liquid hydrogen target (**LqH₂**), scintillation counters (**C1**, **C2** and **A1**) and two scintillation hodoscopes (**H1** and **H2**).

Proportional chambers are placed in the 1st and 2nd focuses of the beam. The chambers are two-coordinate, have square sensitive region of 200×200 mm², 1 mm signal wires pitch, 40 μ m aluminum foil cathode electrodes and 6 mm between the foils. We use "magic" gas mixture (argon-isobutane-freon) to feed the proportional chambers. Beam tests showed efficiency better than 99%.

Main task of the chambers in the 1st focus is to measure the momentum of each pion going to the target. Strong dipole magnets between the internal target and the 1st focus provide horizontal distribution of the particles with different momentum with dispersion

57 mm/%. A distribution over horizontal coordinate in the 1st focus of the events of scattering of the internal beam protons with momentum 1.0 GeV/c over a beryllium internal target is shown in fig. 2. The peaks observed in the picture correspond to (right to left) the elastic scattering, the first excitation of beryllium nucleus and the second and the third excitations seen as one peak.

The liquid hydrogen target has a mylar cylinder container with diameter 40 mm and the length about 250 mm placed in high vacuum inside beryllium outer shell 1 mm thick. It is connected by two pipes to the liquefier system. One is used for liquid hydrogen inflow and through the other the evaporated gas gets back to liquefier. This design provides minimum of matter for the particles. The refrigeration is provided by liquid helium, which flow is controlled by the feedback supporting constant pressure of the hydrogen in the closed volume. This pressure corresponds to proper ratio between liquid and gas fractions of the hydrogen and thus ensuring that the liquid occupies whole target working volume and that the hydrogen is not frozen. Pressures and temperatures in the target system are monitored and logged.

There are 8 one coordinate drift chambers in the elastic setup. 6 chambers have sensitive region $1200 \times 800 \text{ mm}^2$ and for 2 chambers closest to the target it is $600 \times 400 \text{ mm}^2$. The chambers have double sensitive layers hexagonal structure shown in fig. 3. Comparing to the conventional drift tubes this structure has much more complex fields, but provides significantly less amount of matter on the particle path. Potential wires form nearly regular hexagon with a side of 10 mm. Drift chambers are fed with 70% Ar and 30% CO₂ gas mixture. Beam tests showed better than 99% single layer efficiency and about 0.2 mm resolution.

A unique distributed DAQ system based on the commercial 480 Mbit/s USB 2.0 interface was designed for the experiment [11]. It consists of 100-channel boards for proportional chambers and 24-channel boards for drift chambers, placed on the chambers frames. Each board is connected by two cables (USB 2.0 and power) to the communication box, placed near the chamber. Then the data is transferred to the main DAQ computer by the standard TCP/IP connection. Trigger logic is capable of processing of several trigger conditions firing different sets of detectors.

During the engineering run last December and the first physics run in April this year

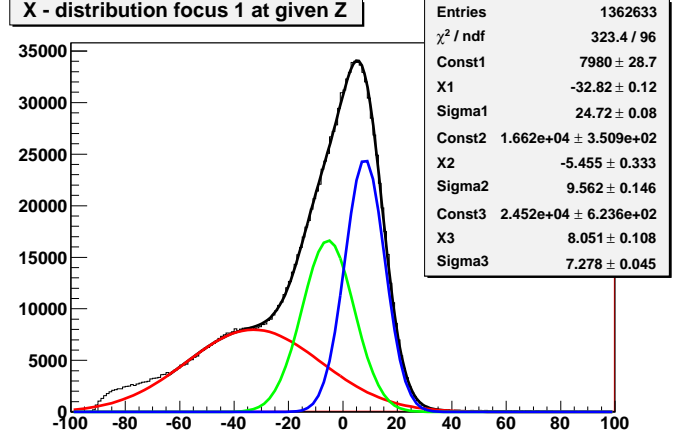


Figure 2: Horizontal distribution in the first focus of internal the accelerator beam protons scattered over internal beryllium target.

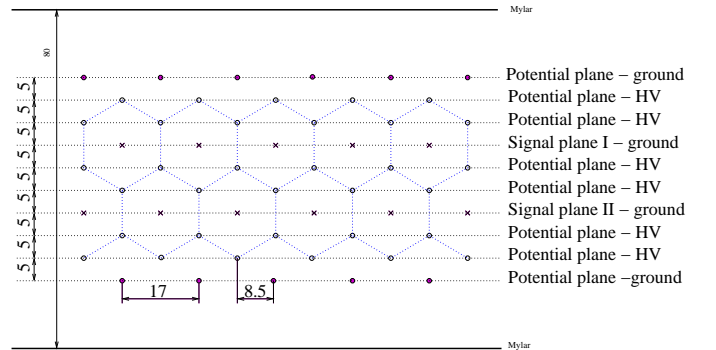


Figure 3: Drift chamber cross section. View along the wires.

the main trigger was set as:

$$T = C_1 \cdot C_2 \cdot M_{1FCH} \cdot M_{2FCH} \cdot \overline{A_1}$$

where C_1 , C_2 and A_1 - signals from corresponding scintillator counters and M_{1FCH} and M_{2FCH} - majority logic of the proportional chamber planes in the 1st and the 2nd focuses. Other trigger conditions were used to provide beam position and luminosity monitoring. To ensure stable beam momentum an NMR monitoring of the magnetic field of the last dipole was used. We collected over $5 \cdot 10^8$ events in the April run, of which we expect about 5% to be elastic events, in the invariant mass range 1640–1745 MeV. Processing of the April run data had started. An example of the elastic events selection for $50^\circ < \theta_{\text{lab}}^\pi < 60^\circ$ is presented in fig. 4. A distribution of the polar angles difference between pion and proton in the center of mass system is shown. A narrow peak corresponds to the correct assumption which of the secondary particles is pion and which is proton. A wide peak correspond to the wrong assumption. This comes from the fact that in the elastic setup we can't distinguish between pion and proton and can only try some assignment and correct events for which it turned out to be wrong.

As a conclusion:

- Construction of the first stage (elastic) of EPECUR has finished and the setup was successfully commissioned.
- Data taking has started this year and the first $5 \cdot 10^8$ events were collected.
- Data processing is under way.
- We are going to take more runs.
- We are going to proceed to the construction of the second stage (KA-production) simultaneously with data taking.

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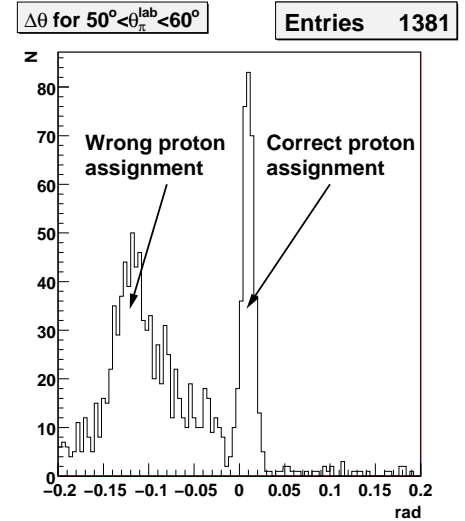


Figure 4: $\Delta\theta^{\text{CM}}$ distribution for θ_{lab}^π range $50^\circ - 60^\circ$.

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